PCT/EP 00/00217

PHN 17285 PC

Europäisches Patentamt

European Patent Office

Office européen des brevets

4

REC'D 14 MAR 2000

WIPO PCT

EPO - DG 1

- 3. 03. 2000

(63)

Bescheinigung

Certificate

Attestation

EP00/217

Die angehefteten Unterlagen stimmen mit der ursprünglich eingereichten Fassung der auf dem nächsten Blatt bezeichneten europäischen Patentanmeldung überein.

The attached documents are exact copies of the European patent application described on the following page, as originally filed.

Les documents fixés à cette attestation sont conformes à la version initialement déposée de la demande de brevet européen spécifiée à la page suivante.

09/623945

Patentanmeldung Nr. Patent application No. Demande de brevet n°

99100580.2

PRIORITY DOCUMENT
SUBMITTED OR TRANSMITTED IN COMPLIANCE WITH RULE 17.1(a) OR (b)

Der Präsident des Europäischen Patentamts;
Im Auftrag

For the President of the European Patent Office

Le Président de l'Office européen des brevets
p.o.

I.L.C. HATTEN-HECKMAN

DEN HAAG, DEN
THE HAGUE, 28/01/00
LA HAYE, LE

EPA/EPO/OEB Form 1014 - 02.91

Europäisches Patentamt | European Patent Office | Office européen des brevets

Blatt 2 der Bescheinigung
Sheet 2 of the certificate
Page 2 de l'attestation

Anmeldung Nr.:
Application no.: 99100580.2
Demande n°:

Anmeldetag:
Date of filing: 13/01/99
Date de dépôt:

Anmelder:
Applicant(s):
Demandeur(s):
Internationaal Octrooibureau B.V.
5656 AA Eidhoven
NETHERLANDS

Bezeichnung der Erfindung:
Title of the invention:
Titre de l'invention:
Embedding supplemental data in an encoded signal

In Anspruch genommene Prioriät(en) / Priority(ies) claimed / Priorité(s) revendiquée(s)

Staat: State: Pays:	Tag: Date: Date:	Aktenzeichen: File no. Numéro de dépôt:

Internationale Patentklassifikation:
International Patent classification:
Classification internationale des brevets:
/

Am Anmeldetag benannte Vertragstaaten:
Contracting states designated at date of filing: AT/BE/CH/CY/DE/DK/ES/FI/FR/GB/GR/IE/IT/LI/LU/MC/NL/PT/SE
Etats contractants désignés lors du depôt:

Bemerkungen:
Remarks:
Remarques:

Internationaal Octrooibureau B.V.

Embedding supplemental data in an encoded signal

FIELD OF THE INVENTION

The invention relates to an arrangement and to a method for embedding supplemental data in an encoded signal.

BACKGROUND OF THE INVENTION

There is a growing need to accommodate supplemental data in encoded data like encoded audio and video signals, preferably without increasing the data rate. Especially if the supplemental data is used as watermarks, it should be added in a perceptually invisible manner. Watermarks may comprise information, for example, about the source or copyright status of documents and audio-visual programs. They can be used to provide legal proof of the copyright owner, and allow tracing of piracy and support the protection of intellectual property.

The Super Audio Compact Disk (SACD) format, for example, specifies lossless coding (LLC) to allow about twice as much data effectively on the disc. The lossless coder is required to allow a playing time of up to 74 minutes of multi-channel audio in SACD quality. As the word lossless coding points out, the required storage capacity of any data is reduced in a way that after decoding the original signal is reproduced bit identical. Such an encoder / decoder is described for instance in Fons Bruekers, Werner Oomen, René van der Vleuten, Leon van de Kerkhof, Improved Lossless Coding of 1-Bit Audio Signals, Audio Engineering Society, 103rd Convention 1997, September 26-29, New York, 4563 (I-6). Encoding is performed by partitioning an input data stream into frames and determining for each frame a set of optimised parameters. Part of these parameters are used for prediction to remove redundancies. The difference between original signal and the prediction signal, which is called residual signal contains very

less relevant information, if good prediction parameters could have been found. As lossless coding is intended, the residual signal can not be omitted, but if it contains less relevant information it can be entropy encoded very efficiently using some other part of the optimised parameters. As the redundant information is held in the parameter set the parameter set as well as the entropy encoded residual signal are stored and needed for lossless decoding.

If supplemental information is needed, for instance for purposes of watermarking, it may be added - as it is fairly wide known – by adding it to the original signal, in a way, that the signal amendment will not be remarked by a listener. Anyway a signal altered like this could no longer be considered as an (bit true) original signal. Additionally this kind of watermarking suffers from the fact, that it is not possible to detect watermarks present in the encoded signal without lossless decoding. For the reason of simplicity of the watermark decoder it is desirable to have the option to detect watermarks prior to lossless decoding

OBJECT AND SUMMARY OF THE INVENTION

It is an object of the invention to provide an arrangement and a method of embedding supplemental data in an encoded data signal, which allows reading the embedded supplemental data without decoding the whole signal and does not influence music quality.

To this end a method according to the invention is characterised in that for embedding supplemental data the supplemental information is inserted into the data and the auxiliary information needed to encode the supplemental data is derived from other data available in the encoding process.

The advantage of the invention is, that by inserting the data into the data to be encoded,

the supplemental information can not be removed without disturbing the content of the encoded signal. As the auxiliary information needed to encode the supplemental information is derived from other data available in the encoding process, the auxiliary information to encode the supplemental data must not be recorded or stored for a later decoding process. Thus this method is very economic with respect to the bit rate.

It is another object of the invention to give an alternative to the first solution.

To this end, a further method according to the invention is characterised in that for embedding supplemental data into the encoded signal the parameter set is affected by the supplemental data. Thus not all the complete data has to be decoded to read a watermark, but only the part of the data where the parameters used for encoding/ decoding are contained. As the supplemental information is embedded in the parameter set, no additional bit has to be spend for this information.

The supplemental information may be embedded by choosing an even or odd number of parameters or by changing the least significant bit of e.g. the first parameter. As an example an even number of parameters represents the value '1' of a watermark bit; an odd number of parameters represents the value '0' of a watermark bit.

The invention takes advantage of the fact that for practical reasons (computation power, costs, ...) not the best set of parameters is determined for encoding, but a somehow quite good set of parameters. Therefore those algorithms have been designed to work with a suboptimal set of parameters as a rule. Therefore small changes in the parameter set, like changing the least significant bit of a parameter, adding a dummy parameter in order to achieve an odd or even number of parameters, whatever is needed to embed a watermark bit or even omit an parameter in order to achieve the odd or even number of parameters will have no huge impact on the encoding efficiency normally. Sometimes such a small variation of the parameter set may even marginally improve the encoding process.

An advantage of the invention is, that, if the data should be kept in lossless coded form, the watermarks cannot be removed without decoding the signal and repeated lossless encoding the data with an altered set of parameters. As the lossless decoder requires all coefficients a missing or wrong coefficient, which has been removed or changed to delete the watermark will result in a signal loss for the duration of a frame for all channels.

DESCRIPTION OF EMBODIMENTS

Fig. 1 shows an arrangement for embedding two independent supplemental data x, y into a lossless coded signal. First data x are used to embed a watermark information w. As the length of the watermark w is longer than the information that could be stored by the supplemental data, the watermark w is packaged by a package generator 1 to a transport packet, which enables to embed the bits of the data package like a serial signal. By means of a synchronisation pattern included in the header of the transport packet the beginning of the transport packet could be retrieved easily. The bits x of the transport packet are embedded bit by bit to the lossless coded signal as so called DST_X_Bits.

Second data y is embedded by so called DST_Y Bits. At current an embedded DST_Y_Bit is set to the value '1' to indicate that the lossless coded signal applies to the up to date format. If there will occur any need in future to have a flag the DST_Y_Bit may be used. It should be obvious to the person skilled in the art that in other recording systems, the DST_Y Bit may also be used in the form of a structured data stream to embed information longer than a single bit.

In order to encode n parallel data streams, which are referred to as data channels C_0 ... C_{n-1}, the stereo or multi-channel DSD recordings are partitioned into frames. In the

embodiment of the invention seventy five frames per second are used for each channel C_i. Although the data rate of the watermark signal w depends on the frame rate, the invention is not restricted to a special frame rate.

For each frame a control arrangement, which is not shown as it is not a part of the invention, discriminates which mode is used for coding: LLC Plain mode or LLC Coded mode. The LLC Plain mode is used in exceptional cases if the compression ratio of a frame is insufficient, and actually contains plain DSD.

The chosen LLC algorithm is based on a prediction filter and a probability table. To optimise the compression ratio of the LLC Coded mode a parameter control unit 4 analyses every frame again each channel separately. The parameter control unit 4 calculates for each channel C_i a set of prediction filter coefficients $A_i = a_i(1) \ldots a_i(k_i)$ for each prediction filter and a set of probability table coefficients $\Pi_i = \pi_i(1) \ldots \pi_i(m_i)$ for each probability table. In the embodiment of the invention the length of a prediction filter coefficient a_i is nine bit, whereas the number k_i of prediction filter coefficients is variable, but is restricted to a maximum value of 128. Each probability table coefficient π_i has a length of seven bits. The number m_i of the probability table coefficients π_i is also variable, restricted by a maximum value of sixty four. Typically it is between thirty two and sixty four. These numbers are given as an example and represent the numbers which have been found to give best results for audio signals, but should not be interpreted as an restriction of the invention to those numbers. The numbers of course depend on the frame rate, the prediction filter algorithm and the content of the source signal. However it is possible that other numbers might be found, which will allow a better compression ratio.

Determining optimal coefficients a, π is difficult and requires considerable computing power. Therefore a compromise is made to select just a quite good set of coefficients. As a separate coefficient set A_i, Π_i s calculated for each channel C_i, the coefficient sets used for each channel will differ from each other, but must not in any case.

To insert an DST_Y_Bit into a frame a flag generator 3 alters the last significant bit LSB of the first filter coefficient $a_0(1)$. As already mentioned before by slightly altering the filter coefficients no substantial decrease in encoding performance should be realised.

All the coefficients of the sets A and Π including the modified coefficient $a_0(1)$ are substantial for the encoded signal and thus must be recorded for a later read or decoding process. As the all coefficient sets A as well Π still contain some redundancy a first and a second compressor 5, 6 is used to generate compressed data words A', Π'. Preferably a compress algorithm is used, which will allow the corresponding decompression of A' and Π' in an most easy way, so that reading the embedded DST_Y_Bit could be done without big efforts.

It is important that the coefficients, the value of which have been modified are also used for the lossless encoding instead of the original evaluated coefficients. Otherwise the decoding process will fail. The function of the lossless encoder is split up in this embodiment of the invention into an encoding predictive unit 7 for each channel C_i and an arithmetic encoder 9 common to all encoding predictive units 7. The structure of an encoding predictive unit 7 is shown in figure 2.

A encoding predictive unit 7 comprises a predictive filter 71 which is initialised with the corresponding filter parameter set A_i. By means of a level converter 72 a binary '0' of the input signal x_i is converted into the numeric value '-1' and a binary value '1' is converted into the numeric value '+1' prior to input the input signal to the predictive filter 71. The output signal of the predictive filter 71 is quantised by a first and a second quantiser 73, 74. The output signal of the first quantiser 73 is exored with the input signal x_i by means of a EXOR gate 75 and forms the residual signal e_i, which is the first of two output signals of the encoding predictive unit 7. The output signal of the second quantiser 74 serves as an index α_i for a probability table stored in an array 76. The

probability table consists of the probability parameter set Π_i. The output signal of the array 76 forms the second output signal of the encoding prediction unit 7, the probability signal p_i. The usage of the probability table is described in greater detail in the paper cited in the opening paragraph.

A multiplexer 8 merges the residual signals c_0 ... c_{n-1} into c as well as the probability signals p_0 ... p_{n-1} into p. The output of the watermark generator 2 is also fed to one input of the multiplexer 8. To embed the DST_X_Bits of the watermark information the mulitplexer 8 inserts the DST_X_Bit in front of c. Due to the design of the arithmetic coder 9 a probability coefficient to code the DST_X_Bit, hereafter referred to as the watermark probability coefficient p_w is indispensable. To save storage space in the embodiment of the invention the watermark probability coefficient p_w is derived from the first predictive filter coefficient $a_0(1)$. Hereto the first predictive filter coefficient $a_0(1)$ of the first channel is fed to a watermark probability module 10. By means of this module the first seven bits of the coefficient $a_0(1)$are interpreted in reverse order as an unsigned integer number D to which the value 1 is added. By using a derived value for the watermark probability coefficient a recording of the watermark probability coefficient is not necessary and requires no supplemental bit in the encoded data block. In this way embedding the DST_X_Bit will lengthen the coded LLC block only marginally.

The arithmetic coder 9 generates from the signal c and the probability signal p the Coded DSD signal.

As the DST_X_Bit is inserted as the first bit of each block to be coded by the arithmetic coder 9, the DST_X_Bit may not be located as a single bit in the Coded DSD signal. Therefore it can not be removed without decoding the Coded DSD signal. Deleting or changing one or some bits inevitably will cause a data loss of data of the whole frame. On the other hand to read a watermark a rudimentary arithmetic decoder is sufficient. Hence it meets the ideal of a watermark in a perfect manner: difficult to remove but

easy to read. However it is not mandatory to insert the DST_X_Bit in front of the signal c, but it will slightly simplify the decoding process of the watermark, as only the beginning of the Coded DSD signal has to be evaluated.

The following table shows the rough syntax of a frame coded in the LLC Coded Mode:

LLC bit	CNTRL	A'	Π'	CODED DSD

The bit LLC in this case has the value '1' to indicate a LLC Coded mode data block. The bits of the CNTRL sub block contain some control information, as for example the number k_i of prediction filter coefficients and the number m_i of probability coefficients of a given channel Ch_i. The next two sub blocks A' and Π' contain the sets of the prediction filter coefficients A and the probability coefficients Π in compressed form. The last block CODED DSD finally contains the coded DSD signal. As explained earlier, the length of the data blocks A, P and CODED DSD varies from frame to frame.

The LLC Coded data blocks are written to a data carrier like a SACD or a DVD for example. As the writing process to the data carrier and the reading process from the data carrier is not part of the invention, but a lot of appropriate means are known to the person skilled in the art, this is not described herein but symbolised by the dashed line 11 and referred to as disk interface.

In the reading device, here in the embodiment of the invention a SACD or a DVD disc player for example, a data block is detected as being a LLC Coded block if the first bit, the LLC-Bit has the value '1'. In this case the data block, is divided into its sub blocks A', Π' and CODED DSD by means of the data contained in the control data block CNTRL. The sub blocks A' and Π' are decompressed by a first and a second decompressor 12, 13 to regain the coefficient sets A_i, Π_i. For each channel a separate decoding prediction unit 14 is foreseen, each decoding prediction unit 14 comprising a

predictive filter and a probability table. At the beginning of decoding a LLC encoded block the coefficient sets A_i, H_i are loaded to the appropriate prediction filters and probability tables of the decoding prediction units 14.

The decoding predictive units 14 are also reconstructing the probability signals $p_0 \dots p_{n-1}$, which are combined to the signal p by a multiplexer 15 of the reading device to the signal p. The signal p is fed to an arithmetic decoder 16 which by means of the probability signal p decompresses the data contained in the sub block CODED DSD to a data streams e. By means of a demultiplexer 17 the data stream e is split into the different residual signals $e_0 \dots e_{n-1}$ of the individual channels and fed to decoding prediction units 14.

The structure of a decoding prediction unit 14 is shown in figure 3. The residual signal e_i of each channel is fed to a first input of an EXOR gate of the decoding sub unit. The output of the EXOR gate forms the output signal of each channel Ch_i. The output signal is also fed to a level converter, which perform the same operation as the level converter in the recording device described earlier. The output of the level converter is fed to the predictive filter. The output of the filter is fed to two quantisers. The output of the first quantiser is connected with the second input of the EXOR gate, the other output of the quantiser is used as an index α_i for the probability table stored in an array. The values p_i of all which is selected by the index α_i are fed via the multiplexer to the arithmetic decoder.

A flag detector 18 is used to reconstruct the embedded DST_Y_Bits. As the DST_Y_Bit is stowed in the first coefficient, only the beginning of the compressed A' block has to be examined by the flag detector 18. The flag detector 18 decompresses only the beginning of the A' block and picks out the first filter coefficients $a_0(1)$ of the first channel and analyses the least significant bits of it to decide the value of the DST_Y_Bit. As the compressing algorithm for the A and H blocks was chosen to enable easy decompression, the watermark detector could be designed very primitive

compared to the total decoder.

To extract the watermark w, the coefficient $a_0(1)$ determined by the watermark flag detector 18 is fed to a watermark probability module 19 of the reading device. The watermark probability module calculates as described for the recording device the watermark probability coefficient p_w. The watermark probability coefficient p_w is fed to the arithmetic decoder to decode the DST_X_Bit. As the DST_X_Bit is the first bit outputted by the arithmetic decoder, it can easily be extracted out by a watermark detector 20. However with a more sophisticated detector it may be extracted from anywhere in the signal, wherever it has been decided to insert it. A formatter 21 extracts from the DST_X_Bits, which are reconverted from a serial bit stream to data block with the help of the synchronisation pattern the watermark information w.

Although the watermark detection function could have been integrated into the other decoding means of the reading device, this structure shows, that a watermark detection could be done stand alone. There is no need to decode the whole coded DSD signal. Therefore the watermark flag detector 18, the watermark probability module 19, the watermark detector 20 and the formatter 21 also could integrated in a device of its own and be run without the more complicated functions incorporated in the decoding prediction units 14 for instance.

Up to now the LLC Coded mode has been described. As described above, sometimes if encoding fails to reduce the bit rate the signal can just be stored as plain DSD. This data mode is named LLC Plain mode and shown just below:

LLC Bit	DTS_X Bit	Plain DSD

The LLC bit is set to the value of '0' to indicate that the frame contains Plain DSD. The bit following to the LLC Bit is used to store the DTS_X_Bit of the watermark in plain format. The DTS_X_Bit is followed by the Plain DSD data. By this it is ensured, that

every coded block contains a DTS_X_Bit, regardless if it is a Coded DSD or a Plain DSD block. This has the advantage that the serial data stream of the DST_X_Bits does not depend on which format is used. On the other hand it is true that the plain DTS_X_bit of a Plain DSD could be changed without making harm to the signal content of a block in Plain DSD.. But as a Plain DSD block is the exception in the big majority there will be more than enough uninterrupted Coded DSD blocks, to carry the watermark in full length.

In a further embodiment of the invention more than one supplemental bit is embedded into the lossless coded signal, by changing more than one LSB of the parameters. To embed two bits per frame for instance the first and the second predictive filter coefficient $a_1(0)$, $a_2(0)$ of the first audio channel are unused. These two bits may be used to represent the following information:

LSB $a_0(1)$	LSB $a_0(2)$	Meaning
0	0	Watermark bit '0'
0	1	Watermark bit '1'
1	0	Synchronisation symbol
1	1	Reserved for future use

As only one watermark bit is foreseen to be used in each frame, the watermark information has to be written in a serial data format. Therefore the synchronisation symbol '10' serves to detect the beginning of the watermark information.

1. Method for encoding data (e) by means of auxiliary information (p), characterised in that for embedding supplemental data (x) the supplemental information (x) is inserted into the data (e) and the auxiliary information (p_w) needed to encode the supplemental data is derived from other data ($a_0(1)$).

2. Method for extracting supplemental data of encoded data as defined in claim 1.

3. Method for encoding input data by partitioning the data into frames, determining for each frame a set of parameters, reducing the data of the input signal by applying an algorithm which is controlled by the parameter set whereby the encoded data comprises the set of parameters or at least data which can be used to derive the parameter set and the data rate reduced signal. characterised in that for embedding supplemental data (y) into the encoded signal the parameter set is affected by the supplemental data (y).

4. Method for extracting information which is embedded in the parameter set of an encoded signal as defined in claim 3.

5. Signal comprising encoded data according to claim 1 or 3.

6. Data carrier with a recorded signal according to claim 5

7. Arrangement for performing a method according to claim 1, 2, 3 or 4.

8. Playback device with an arrangement described in claim 2 and/or 4.

9. Playback device according to claim 7 characterised that it is a Disk player for audio

and audio-visual media respectively.

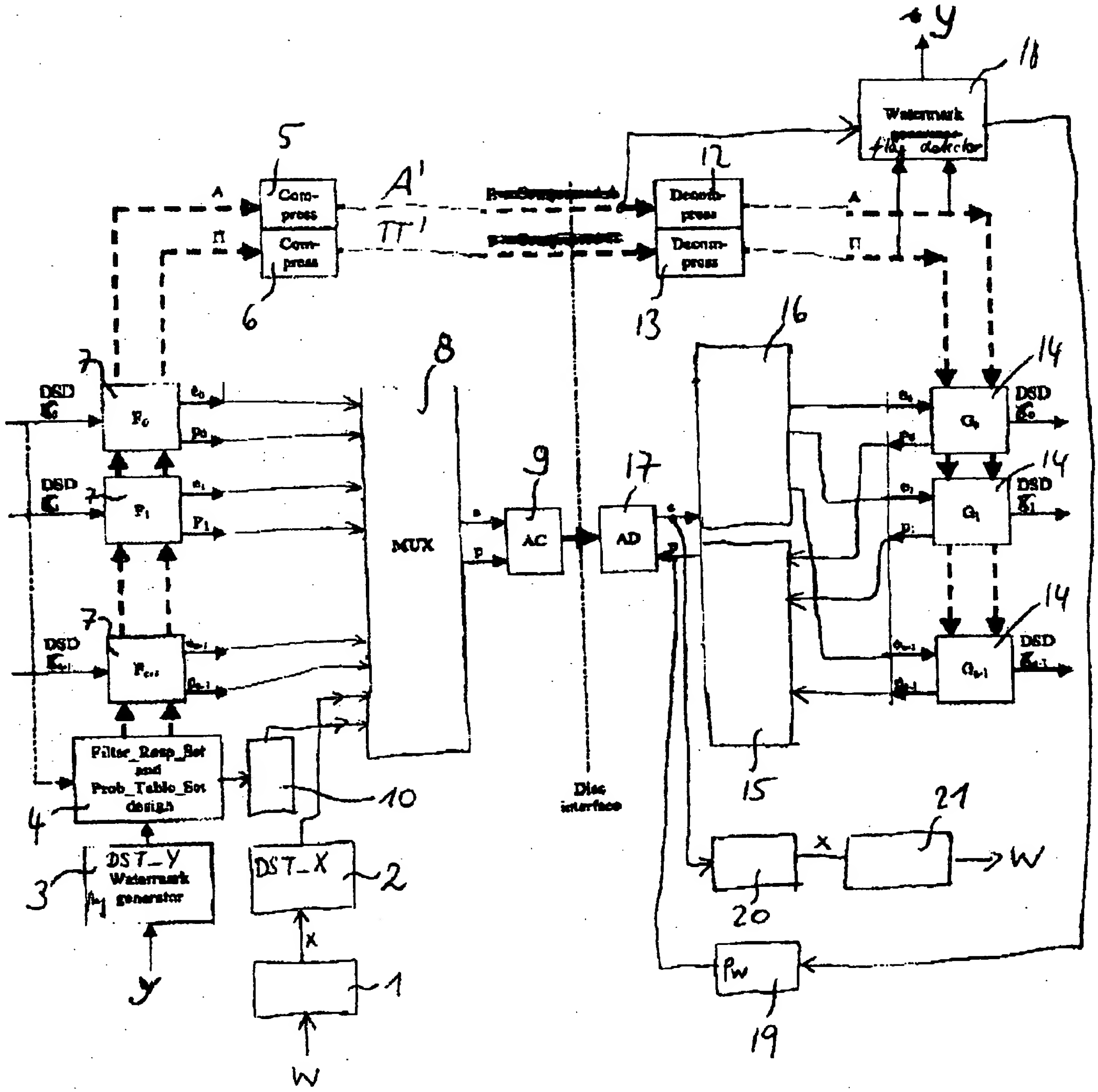

Fig. 1

PHN 17285 EP-P

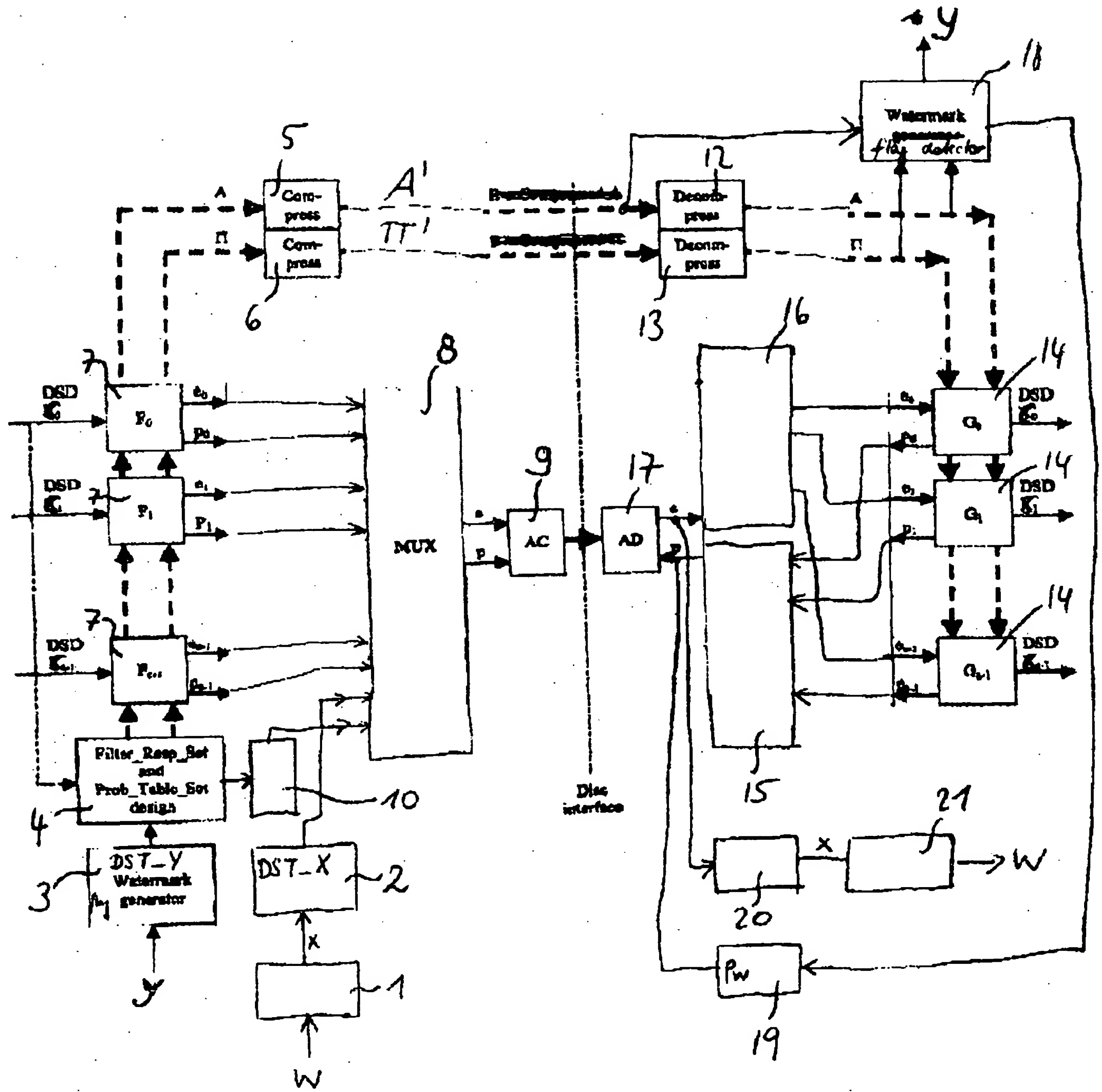

Fig. 1

PHN 17285 EP-P

and audio-visual media respectively.